STATUS REPORT

In the status report for March 1 through May 31, 1962, experiments with single CdS crystals activated with copper were reported, which showed that such single crystal can very successfully be used as elements for a memory device. The most interesting feature of these crystals were: The relatively large size of their polarization--up to 10^{-7} coul/cm^2 were observed--the long decay time of this polarization--half value decay time of 1000 sec were observed, and their very rapid rise and release times. In order to study how the polarizations of these crystals are affected by additional electric fields, the following experiments were carried out. They give very good insight into the processes leading to polarization of the crystal and into those causing the release of polarization.

The results are presented in Table 1. The procedure was similar to that previously described, but instead of applying a field of one polarity, fields of different polarities were applied subsequently. The reason for this procedure was to find out how the polarization produced by one polarity was influenced by a subsequently applied field of opposite polarity. It will be shown later that the procedure of reversed field can be successfully used to accelerate the readout time of the polarization.

The experiments with crystal X55 were carried out in the following way. The crystal was illuminated with white light, then kept in the dark for 30^s, then irradiated with I.R. for 30^s. One second thereafter, a voltage V_{1c} was applied at the conductive side for 30^s; 1 sec. after removal of V_{1c}, another voltage V_{2c} was applied for 30^s. 10 sec. thereafter the polarization release was carried out. The voltages were applied for 30 sec. in order to have identical conditions always. It was, however, observed that 80% of the

Table 1

X-55 $1^m W_n, 30^s dQ, 30^s IRQ_n, \xrightarrow{1\ sec} P\ (n = 0;\ V_{1c},\ 30^s;dark) \xrightarrow{10\ sec.} R(UV,\ +\ white,\ 15^s)$

RELEASE

+ charge implies positi ~ charge moves to conductive electrode
Q(UV) - charge release upon radiation of UV
Q(W) - charge release upon radiation of white
charge in units of 10^{-11} col/cm^2

1	V_{1c}	V_{2c}	QUV_c	QW_n	QUV_n	QW_c
2	+200	0	+6	(-0.5)	(-0.3)	+4.8
3	+400	0	+7	(+0.5)	0	+6.6
4	0	-200	-12	-17	-38	(+1)
5	+200	-200	-17	-17	-39	(+1.5)
6	+400	-200	-15	-15	-42	+3
7	0	-400	-69	-108	-260	(-5)
8	+200	-400	-78	-102	-265	(-5)
9	+400	-400	-33	-78	-255	(-10)
10	0	+200	+25	0	0	+8.0
11	0	+400	+22	(-1)	0	+17
12	-200	0	-5	-13	-24	(+2)
13	-200	+200	+13	-8	-6.3	+8.1
14	-200	+400	+19	-4	-3	+14
15	-400	0	-45	-138	-210	0
16	-400	+200	-23	-132	-162	0
17	-400	+400	-37	-78	-156	(-6)

Parentheses indicate magnitude is of such small scale that it is doubtful.

final polarization was already obtained in much less than 1 sec.

The releases were performed either with U.V. light which is completely absorbed in the crystal within a small fraction of its thickness or with white light (W) which excites the crystal almost uniformly. Illumination was carried out either from the conductive side $U.V._c$, W_c, or from the non-conductive side $U.V._n$, W_n. The charges measured on the electrometer upon illumination are given in the table as QUV and QW. Release with white light was always carried out immediately after the respective polarization with U.V.

The accompanying table gives a good survey about the results obtained when voltages of different polarities and strength are applied. Rows 2 and 3 present the released polarization for 200 and 400 volt positive polarity at the conductive electrode. Positive charges are collected at the barrier, and consequently the U.V. release is strongest when illuminated through the conductive side since then electrons, the more mobile charge, move across the sample to the barrier and discharge the accumulated positive charge there. U.V. illumination through the barrier side does not produce any appreciable discharge because positive charges have to move across the crystal which are, however, less mobile. White light, applied after the $U.V._n$ illumination results in a released charge of the same order of magnitude as QUV_c. If these values are compared with those described in Rows 10 and 11 in which the polarization was carried out as V_{2c}, which is normally applied 30 seconds later than the V_{1c} polarization, one finds that the discharge values are larger in the latter case since the decay times are shorter. The difference between the QUV_c of Rows 10 and 11 and those of Rows 2 and 3 is a measure of the decay of the positive polarization

(V_c positive) within 30 seconds. It is also important to compare the 200 and 400 volt polarization values. It is seen that the increase from 200 to 400 positive voltage does not increase the release charges considerably.

The results are quite different with negative polarity at the conductive side. Compare the results of Rows 12-15 with those of 2 and 3. In this case, the U.V. release on the conductive side is weak, and the U.V. release from the non-conductive side large. Note further the large increase between 200 and 400 volts which does not occur for positive voltages. Compare further with these values Rows 4 and 7 where the equivalent negative voltages are applied as V_{2c}. In this case, there is only a relatively slight decay with time. Especially compare QUV_n for Row 7 and Row 15. The decay for 200 volts is somewhat larger than for 400 volts. For negative voltages--this means for accumulation of negative charge at the barrier--also QUV_c has noticeable values, although when positive charges move from the conductive electrode through the sample to the barrier. This effect was already observed previously and has to be investigated further.

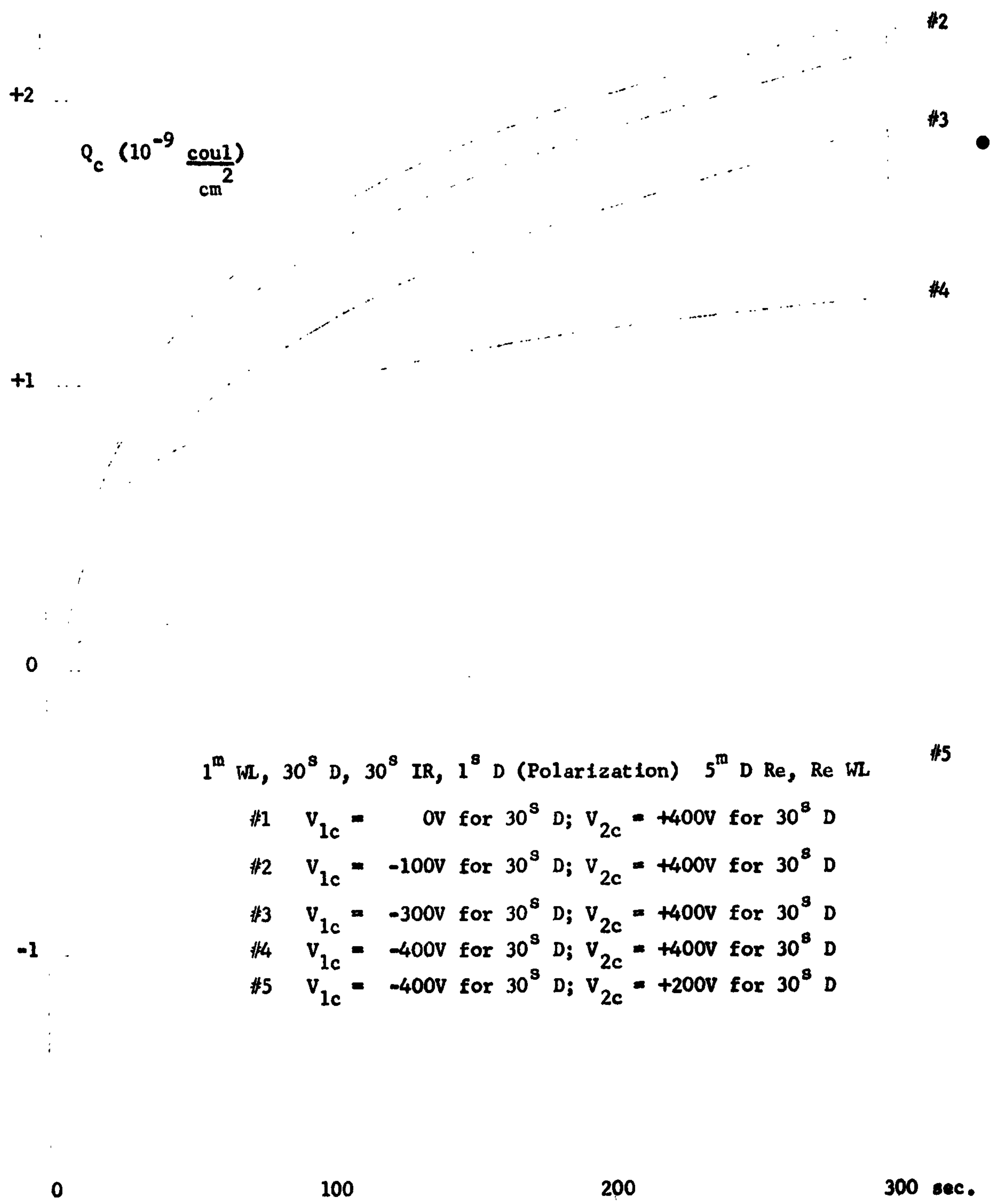
Now we consider the influence of reversed fields on a preceding polarization. First, consider Rows 6, 8 and 9, which present the results of positive polarization with 200 and 400 volt followed by negative polarization. It is seen that subsequent negative polarization reverses the released charge completely. The charge releases obtained under Column QUV_n are almost independent of the preceding polarization with positive voltages, but the QUV_c values are reversed compared with those obtained without reversed fields.

If one applies, however, a positive voltage after a preceding negative voltage at the conductive side, it is found that the influence of the reverse field is much less as shown by the results of Rows 13, 14, 16 and 17. With - 200 volt V_{1c} polarization, the subsequent polarization by + 200 and + 400 volts reduces the QUV_n values to some extent but does not reverse them; only the sign of the weaker QUV_c release is changed; but with - 400 volt V_{1c} polarization the subsequent polarization by + 200 and + 400 volts is still less effective as shown by the respective QUV_n and QUV_c. The releases with white light were only taken to see how much U.V. light had released the polarization. These results show that positive fields are much less effective in polarizing and depolarizing as negative fields.

These results are borne out by the curve of the accompanying figure which gives the release curves for negative polarization at the conductive side and subsequent positive polarization by 200 or 400 volts. First, the decay of polarization was observed in the dark for 300 seconds, and the curves given present this dark release. The dark release is positive for curves 1-4 and first positive and then negative for 5. This means that + 400 volts of the subsequent polarization produces some charge accumulation which decays in the dark rather fast. But even 300 seconds after this polarization, illumination with white light shows a very strong polarization in the direction expected from negative polarization. This means a transport of negative charge from the barrier to the conductive electrode. If these polarizations were released by white light or U.V. not after 300 seconds but after 30 seconds, the release in the negative direction would be much larger. Only for - 100 volts the subsequent

Figure 1

DARK AND WHITE RELEASE AFTER REVERSE POLARIZATION



polarization by + 400 volts resulted in a small positive release. This shows quite obviously the considerable stability of negative polarization from the conductive side.

These results are important because they may enable us to accelerate the readout process by applying an opposite voltage during the release process. It is anticipated that this release will be much faster than the release without such a reverse field. Reverse field methods give further possibilities to erase the preceding polarization without light but with simple field application.

LIST OF RECIPIENTS FOR #048105

001	1	Assistant Sec. of Def. for Res. and Eng.	02 copies
001	2	Information Office Library Branch	
001	3	Pentagon Building	
001	4	Washington 25, D. C.	
002	1	Armed Services Technical Information Agency	10 copies
002	2	Arlington Hall Station	
002	3	Arlington 12, Virginia	
003	1	Chief of Naval Research	02 copies
003	2	Department of the Navy	
003	3	Washington 25, D. C.	
003	4	Attn Code 437, Information Systems Branch	
004	1	Chief of Naval Operations	
004	2	OP-07T-12	
004	3	Navy Department	
004	4	Washington 25, D. C.	
005	1	Director, Naval Research Laboratory	06 copies
005	2	Technical Information Officer /Code 2000/	
005	3	Washington 25, D. C.	
006	1	Commanding Officer, Office of Naval Research	10 copies
006	2	Navy #100, Fleet Post Office	
006	3	New York, New York	
007	1	Commanding Officer, O N R Branch Office	
007	2	346 Broadway	
007	3	New York 13, New York	
008	1	Commanding Officer, O N R Branch Office	
008	2	495 Summer Street	
008	3	Boston 10, Massachusetts	
010	1	Bureau of Ships	
010	2	Department of the Navy	
010	3	Washington 25, D. C.	
010	4	Attn Code 607A NTDS	
011	1	Bureau of Naval Weapons	
011	2	Department of the Navy	
011	3	Washington 25, D. C.	
011	4	Attn RAAV Avionics Division	
012	1	Bureau of Naval Weapons	
012	2	Department of the Navy	
012	3	Washington 25, D. C.	
012	4	Attn RMWC Missile Weapons Control Div.	
013	1	Bureau of Naval Weapons	
013	2	Department of the Navy	
013	3	Washington 25, D. C.	
013	4	Attn RUDC ASW Detection and Control Div.	

016	1	Bureau of Ships
016	2	Department of the Navy
016	3	Washington 25, D. C.
016	4	Attn Communications Branch Code 686
019	1	Naval Ordnance Laboratory
019	2	White Oaks
019	3	Silver Spring 19, Maryland
019	4	Attn Technical Library
020	1	David Taylor Model Basin
020	2	Washington 7, D. C.
020	3	Attn Technical Library
022	1	Naval Electronics Laboratory
022	2	San Diego 52, California
022	3	Attn Technical Library
024	1	University of Illinois
024	2	Control Systems Laboratory
024	3	Urbana, Illinois
024	4	Attn D. Alpert
025	1	University of Illinois
025	2	Digital Computer Laboratory
025	3	Urbana, Illinois
025	4	Attn. Dr. J. E. Robertson
027	1	Air Force Cambridge Research Laboratories
027	2	Laurence C. Hanscom Field
027	3	Bedford, Massachusetts
027	4	Attn Research Library, CRX2-R
028	1	Technical Information Officer
028	2	US Army Signal Research and Dev. Lab.
028	3	Fort Monmouth, New Jersey
028	4	Attn Data Equipment Branch
031	1	National Security Agency
031	2	Fort George G. Meade, Maryland
031	3	Attn R-4, Howard Campaigne
032	1	U. S. Naval Weapons Laboratory
032	2	Dahlgren, Virginia
032	3	Attn Head, Computing Div., G. H. Gleissner
033	1	National Bureau of Standards
	2	Data Processing Systems Division
	3	Room 239, Bldg. 10
	4	Attn A. K. Smilow
	5	Washington 25, D. C.

034	1	Aberdeen Proving Ground, BRL
	2	Aberdeen Proving Ground, Maryland
	3	Attn J. H. Giese, Chief Computation Lab.
053	1	Commanding Officer
	2	ONR Branch Office
	3	John Crerar Library Bldg.
	4	86 East Randolph Street
	5	Chicago 1, Illinois
054	1	Commanding Officer
	2	ONR Branch Office
	3	1030 E. Green Street
	4	Pasadena, California
055	1	Commanding Officer
	2	ONR Branch Office
	3	1000 Geary Street
	4	San Francisco 9, California
057	1	National Bureau of Standards
	2	Washington 25, D. C.
	3	Attn Mr. R. D. Elbourn
058	1	Naval Ordnance Laboratory
	2	Corona, California
	3	Attn H. H. Weider
059	1	George Washington University
	2	Washington, D. C.
	3	Attn Prof. N. Grisamore
070	1	Lockheed Research Laboratory
	2	3251 Hanover, 52-40, Bldg. 202
	3	Palo Alto, California
	4	Attn M. E. Browne
081	1	Stanford University
	2	Stanford, California
	3	Attn Electronics Lab., Prof. John G. Linvill
091	1	Univ. of California - LA
	2	Los Angeles 24, California
	3	Attn Dept. of Engineering, Prof. Gerald Estrin
092	1	University of Maryland
	2	Physics Department
	3	College Park, Maryland
	4	Attn Professor R. E. Glover
093	1	Columbia University
	2	New York 27, New York
	3	Attn Dept. of Physics, Prof. L. Brillouin

100	1	University of Illinois
	2	Champaign Urbana, Illinois
	3	Attn John R. Pasta
101	1	Naval Research Laboratory
	2	Washington 25, D. C.
	3	Attn Security Systems
	4	Code 5266, Mr. G. Abraham
118	1	National Physical Laboratory
	2	Teddington, Middlesex
	3	England
	4	Attn Dr. A. M. Uttley, Superintendent,
	5	Autonomics Division
133	1	Diamond Ordnance Fuze Laboratory
	2	Connecticut Ave. and Van Ness St.
	3	Washington 25, D. C.
	4	ORDTL-012, E. W. Channel
139	1	Harvard University
	2	Cambridge, Massachusetts
	3	Attn School of Applied Science,
	4	Dean Harvey Brook
146	1	Wright Air Development Division
	2	Electronic Technology Laboratory
	3	Wright-Patterson AFB, Ohio
	4	Attn Lt. Col. L. M. Butsch, Jr.
	5	ASRUEB
148	1	Laboratory for Electronics, Inc.
	2	1079 Commonwealth Ave.
	3	Boston 15, Massachusetts
	4	Attn Dr. H. Fuller
149	1	Stanford Research Institute
	2	Computer Laboratory
	3	Menlo Park, California
	4	Attn H. D. Crane
152	1	The Rand Corp.
	2	1700 Main Street
	3	Santa Monica, California
	4	Attn Numerical Analysis Dept.
	5	Willis H. Ware
175	1	Stanford Research Institute
	2	Menlo Park, California
	3	Attn Dr. Charles Rosen
	4	Applied Physics Laboratory

190	1	New York University
	2	New York, New York
	3	Attn Dr. J. H. Mulligan, Jr.
	4	Chairman of E. E. Dept.
191	1	Marquardt Aircraft Company
	2	16555 Saticoy Street
	3	P. O. Box 2013 - South Annex
	4	Van Nuys, California
	5	Attn Dr. Basun Chang, Research Scientist
192	1	Texas Technological College
	2	Lubbock, Texas
	3	Attn Paul G. Griffith
	4	Department of Electrical Engineering
197	1	L. G. Hanscom Field /AF-CRL-CRRB/
	2	Bedford, Mass.
	3	Attn Dr. H. H. Zschirnt
202	1	Department of the Army
	2	Office of the Chief of Research and Development
	3	Pentagon, Room 3D442
	4	Washington 25, D. C.
	5	Attn Mr. L. H. Geiger
233	1	General Electric Research Lab.
	2	P. O. Box 1088
	3	Schenectady, New York
	4	Attn V. L. Newhouse
	5	Applied Physics Section
234	1	The George Washington University
	2	Logistics Research Project
	3	707 22nd Street, N. W.
	4	Washington 7, D. C.
	5	Attn Joseph Fennell
238	1	Harshaw Chemical Co.
	2	1945 East 97th Street
	3	Cleveland 6, Ohio
	4	Attn Mr. A. E. Middleton
262	1	National Bureau of Standards
	2	Office of Basic Instrumentation
	3	Washington 25, D. C.
	4	Attn Dr. Joshua Stern
295	1	University of Pennsylvania
	2	Moore School of Electrical Engineering
	3	200 South 33rd Street
	4	Philadelphia 4, Pennsylvania
	5	Attn Miss Anna Louise Campion

331	1	Applied Physics Laboratory
	2	Johns Hopkins University
	3	8621 Georgia Avenue
	4	Silver Spring, Maryland
	5	Attn Document Library
333	1	Bureau of Supplies and Accounts, Chief
	2	Navy Department
	3	Washington, D. C.
	4	Attn Code W3
336	1	Mr. E. J. West
	2	Code 6440
	3	Naval Research Lab
	4	Washington 25, D. C.
339	1	U. S. Naval Avionics Facility
	2	Indianapolis 18, Indiana
	3	Attn Librarian, Code 031.2
341	1	Prof. E. L. Hahn
	2	Dept. of Physics
	3	University of California
	4	Berkeley 4, California
351	1	Federal Aviation Agency
	2	Bureau of Research and Development
	3	Washington 25, D. C.
	4	Attn RD-375, Mr. Harry Hayman
352	1	Commanding Officer
	2	U. S. Army Signal Research and Development Lab.
	3	Fort Monmouth, New Jersey
	4	Attn SIGFM/EL/PEP/R. A. Gerhold
353	1	Commander Rome Air Development Center
	2	Griffis Air Force Base
	3	New York
	4	Attn RCLMA, J. Dove
354	1	McDonnel Aircraft Corporation
	2	Missile Engineering Division
	3	Municipal Airport
	4	St. Louis, Missouri
	5	Attn Manager, Adv. Digital Techniques, R. E. Acker
366	1	Chief, Bureau of Ships
	2	Code 671A2
	3	Washington, D. C.
	4	Attn LCDR. E. B. Mahinske, USN

373	1	Lincoln Laboratory
	2	Massachusetts Institute of Technology
	3	Lexington 73, Massachusetts
	4	Attn: Library
380	1	Division of Electronics Materials
	2	Kyoto University
	3	Institute for Chemical Research
	4	Kyoto, Japan
	5	Attn Tetsuro Tanaka
422	1	Waddell Dynamics, Inc.
	2	5770 Soledad Road
	3	La Jolla, California
	4	Attn: B. L. Waddell, President
536	1	Institute for Defense Analysis
	2	Communications Research Division
	3	Von Neumann Hall
	4	Princeton, New Jersey
582	1	L. Freinkel
	2	U. S. Naval Ordnance Test Station
	3	Pasadena Annex
	4	3202 E. Foothill Blvd.
	5	Pasadena 8, California